New Homes

What is an Energy Efficient Home?

An energy efficient home is more than just a collection of individually efficient parts. It is a total system that must work as a whole. Planning how the parts fit is crucial to building a home that is efficient, safe and reliable.

Energy efficient homes probably look like any other home in the neighbourhood. The things that save energy are hidden in the foundations, walls, ceilings and mechanical systems. They add seven to 10 per cent to the cost of construction, but result in a more comfortable home with fuel bills 35 to 55 per cent lower.

The key elements of an energy efficient home are:

- high insulation levels
- careful sealing for airtightness
- controlled mechanical ventilation
- well designed and controlled heating system
- properly designed windows in well-chosen locations

You have many choices on how to incorporate these elements and to what degree. Energy efficient homes range from well-insulated to super-insulated, from mostly fuel-heated to mostly solar-heated. They can be built with a variety of framing and sealing techniques, foundation and window types, and heating and ventilating systems.

This booklet describes choices in energy efficient home design and the building science principles they must respect. It outlines the advantages of energy efficiency and reviews basic design decisions, the elements of energy efficient construction, alternative framing systems, and economics.

Energy efficient housing is an innovative response suitable to Alberta's northern climate. As more homes are built, more techniques and products become available. If you are planning an energy efficient home, call the Energy Matters hotline at Zenith 22339 (427-5300 in Edmonton) to find out the latest developments.

Why Build an Energy Efficient Home?

Energy efficient homes have comfort, health, safety and environmental advantages over conventional homes. They also have smaller utility bills. Alberta's gas prices, however, make many construction techniques described here uneconomic at this time. The techniques are included because economics is not the only reason to choose an energy efficient home. Houses have a 50-year lifespan and wise homeowners prefer a home which is economical to operate over the years.

Energy efficient homes are more comfortable due to high levels of insulation and careful air sealing. A well-insulated home is warmer in winter and cooler in summer. Energy efficient homes are also quieter because insulation is a soundproofing material.

Airtightness means fewer drafts, less dust and better control over indoor air quality. While conventional homes rely on haphazard air leaks for fresh air, well-sealed homes use mechanical ventilation which is controlled and monitored. People who have switched to an energy efficient home list better indoor air quality as a comfort and health advantage.

Air supply to a fuel-burning unit receives particular attention in energy efficient homes to ensure their safe operation. The possibility of harmful combustion gases escaping into the house because of inadequate ventilation for these appliances is low. Some homes are built with heating units that eliminate the risk altogether.

Energy efficient homes burn less fossil fuel. Greenhouse gases such as carbon dioxide (which are released during combustion) are therefore reduced. This helps preserve the environment from the changes of global warming and ozone depletion.

Comfort, health, safety, and environment are important advantages and can outweigh economics as reasons to build an energy efficient home. The economics of energy efficiency, however, will improve if energy prices rise. Building an energy efficient home is much less expensive than trying to improve a conventional home later.

Energy Design Decisions

Planning the house involves a series of related decisions, as Figure 1 illustrates. The major decisions are: how energy efficient it will be, how much it will rely on passive solar heating and what the floor plan will be.

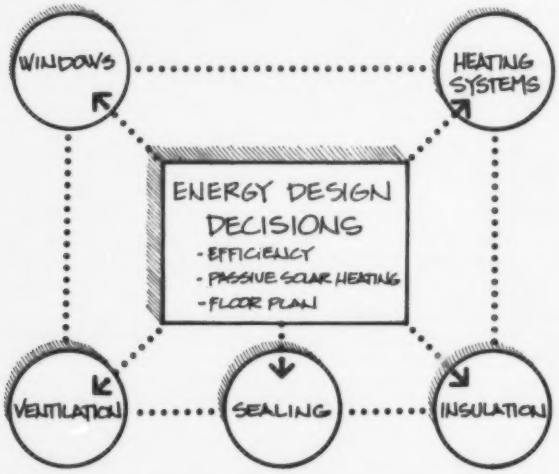


Figure 1 Related Decisions in Planning a home

Any home with south-facing windows can benefit from passive solar heating. To get maximum benefit, more windows should be placed on the south and fewer on the north. Windows facing due south gain the most heat. Windows oriented 30 degrees off south will achieve 90 per cent of the gains of a south-facing window; east- and west-facing windows achieve about 40 per cent. To avoid overheating, the size of south-facing windows should be relative to the floor area and energy efficiency of the house, its mass, and the type of glazing on the south-facing windows. *Passive Solar* explains size in more detail. Too many west and southwest windows will cause overheating due to the late afternoon sun.

While the size and shape of the house affects its energy efficiency, any house can be energy efficient. The floor plan should meet the needs for space and privacy. A smaller house uses less energy and saves on building materials. A shape that minimizes exterior wall area will be more energy efficient because a house loses heat through its outside walls. The closer the floor plan approaches square, the less exterior wall it will require. A rectangular shape facing south, however, takes better advantage of the sun.

Overhanging floors, fireplaces and bow or bay windows are hard to insulate and seal. If you include these in your plan, remember that it takes extra time and effort to prevent them from being cold and drafty.

Elements of Energy Efficient Construction

Energy design decisions require choices on how to incorporate the five key elements of energy efficient construction and to what degree. This section reviews building science principles for each and their relationship to other planning decisions.

Insulation

Principles

Insulation reduces heat loss through the ceiling, exterior walls, windows, doors and foundation. This heat loss is usually described as "heat flow through the building envelope." Heat flow increases as the area of the building envelope and the temperature difference between indoors and out becomes larger; it decreases as the resistance of the building envelope to heat flow becomes higher.

$$\text{heat flow} = \frac{\text{area x temperature difference}}{\text{resistance to heat flow}}$$

Resistance to heat flow is measured in RSI values (to convert RSI values to R values, multiply by 5.678). The more insulation you add, the less heat you lose. In fact, you cut heat flow in half each time you double insulation values. Remember, however, that the amount of energy you save will be less with each increment. For example, if an attic insulated to RSI 1 loses $180 of heat per year, doubling the insulation to RSI 2 would save $90. Doubling again to RSI 4, however, would only save half again or $45.

Attic Insulation describes types of insulation available. The best one depends on the application; for example, only certain rigid insulations can be used for the exterior of foundation walls. You may also want to consider qualities such as fire resistance and weight but as a general rule, use the insulation and framing system that lets you achieve your objectives at least cost.

To be effective, insulation must be installed at an even thickness, without gaps, and to its designed density. It must be protected with a vapour retarder and a continuously sealed air barrier to prevent water vapour from entering and condensing inside the insulated cavity. Proper ventilation in attics and crawl spaces will help control condensation by evaporating any moisture that does enter. Ventilating the attic can control overheating in summer.

Related Decisions

As you consider insulation levels for your home, remember to think about:

- **Insulation levels in the total building envelope.** Your house is a system of integrated components. If you choose high insulation levels for one part, you should also have high levels in other parts. Table 1 outlines some examples of balanced alternatives.

Table 1
Balanced Insulation Levels

	House Type		
House Component	**Standard RSI (R)**	**Well-insulated RSI (R)**	**Super-insulated RSI (R)**
Foundation	2.1(12)	3.5(20)	4.9(28)
Basement floor	0.0	0.9(5)	1.8(10)
Main walls	3.5(20)	4.9(28)	7.0(40)
Ceiling	6.0(34)	7.0(40)	10.6(60)
Windows	0.4(2)	0.6(3.2)	0.6(3.2)

- **Type of framing system.** Some framing systems such as double walls and wall trusses are best for walls of RSI 7 (R 40) or better. Ceiling trusses can be built for any level of insulation. Choose the framing systems that best suit your insulation objectives. In the construction details in the next section, note how the system you choose affects the location of the vapour retarder and the method of insulating the joist space.
- **Size and type of heating system.** The higher the insulation levels, the less heating capacity you need. The smaller heat requirements of energy efficient homes make more heating options practical, such as electric or fuel-fired space heaters.

Sealing for Airtightness

Principles

Energy efficient new homes should be sealed well to prevent heat loss from air leaks and to stop water vapour from entering insulated spaces. Unless controlled, water vapour will enter insulated spaces in two ways: 1) air movement that allows warm moist interior air to move through the building envelope, and 2) vapour pressure that causes water vapour to diffuse through the envelope, independent of air movement.

Air movement is by far the most important process and is controlled by an "air barrier." An air barrier can be made of anything solid enough to withstand wind pressure such as drywall, plywood and structurally supported polyethylene or olefin fibre sheeting. No matter what functions as your air barrier, it must be as uninterrupted as possible. Try to seal it airtight. Anything that pierces it -- electrical outlets, plumbing stacks, exhaust vents, wiring, recessed lights, windows and doors -- must be sealed. Theoretically, an air barrier can be installed anywhere in the building envelope, even on the outside.

Vapour diffusion is controlled by "vapour retarders," which can be made of any impermeable material. Drywall covered with a semi-gloss latex or vapour-retarder paint or sheets of polyethylene are usually used. A vapour retarder should be well sealed. Taking the time to seal it tightly can make up for unanticipated flaws in your air barrier. A vapour retarder must be installed near the warm side of an insulated space to avoid becoming a cold surface where moisture will condense. It can be placed on the inside surface of the insulation under the wall finish or located part way into the wall as long as at least two-thirds of the insulation value of the wall is outside it. (This is valid in Alberta's climate; colder climates require more insulation outside the retarder.)

Figure 2 illustrates the location and function of air barriers and vapour retarders.

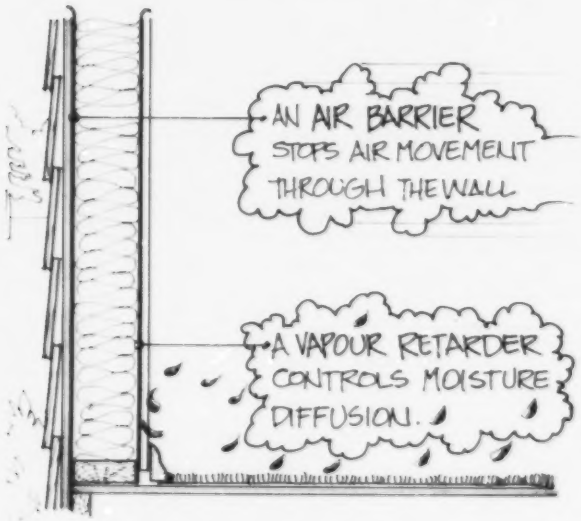


Figure 2 Functions of an Air Barrier and Vapour Retarder

It is standard practice to seal a home with a combined air barrier and vapour retarder (often called an air/vapour barrier) which serves the double function of stopping vapour diffusion and air movement. A combined air barrier and vapour retarder must follow the rules of both. It must be continuously sealed and placed near or on the warm side of the insulation.

Related decisions

Every energy efficient home should be carefully sealed. Sealing your home affects:

- **Ventilation.** You must have mechanical ventilation in a well-sealed house to prevent the accumulation of pollutants and humidity. Fuel-burning appliances must draw combustion air from outside to operate safely and properly.
- **Framing systems.** Plan to accommodate the ductwork for a centralized ventilation system because airtight design requires mechanical ventilation. Framing systems also affect the way your home is sealed with a combined air barrier and vapour retarder. A system that locates the barrier/retarder within an insulated cavity, rather than on the inside of a wall, will protect it from being pierced by wiring or plumbing. Another way to protect your barrier/retarder is to install plumbing and wiring on interior walls as much as possible. Roof trusses, which eliminate the need for load-bearing interior partition walls, allow you to install the barrier/retarder in one piece before adding partitions.
- **Size and type of heating system.** A well-sealed house needs less heating capacity than a conventional house and more heating options are practical.
- **Windows.** Airtight design allows higher indoor humidity. You will want windows with more insulation value than usual because they permit higher levels of indoor humidity without condensation.

Ventilation

Principles

Airtight design and centralized mechanical ventilation go together. Centralized mechanical ventilation uses fans to exhaust stale air and to supply fresh air from outside. In a well-sealed house, you need this type of ventilation to maintain good indoor air quality. It also allows control over the warm air exhausted from your home: a conventional home wastes energy by allowing warm air to leak out at an excessive rate.

The Alberta Building Code requires new homes to have enough mechanical ventilation to replace at least one third the air in a house every hour (0.3 air changes per hour). Have your ventilation contractor size your system appropriately.

Ventilating Your Home describes different kinds of mechanical ventilation systems. Balanced systems that both exhaust and supply air from a single unit are the best in our climate. Some, called "heat recovery systems," use a heat exchanger to warm replacement air with exhaust air.

Even with a ventilation system supplying fresh air, furnaces, fireplaces, wood stoves, gas appliances, and water heaters all require separate combustion air intakes. A lighted fireplace, for example, must draw combustion air from somewhere. If it doesn't have its own air intake, it may draw air down the water heater and furnace chimney. **This results in a dangerous backdraft, where gases from the combustion of fuel are drawn into the house instead of going up the chimney.**

Even with sophisticated ventilation, it's pleasant to be able to open a window. Windows that open provide summer ventilation and solve a short-term overheating problem. They are not, however, reliable for proper ventilation throughout the year.

Related decisions

The decision to build an energy efficient, well-sealed home means you must have mechanical ventilation. The type of mechanical ventilation you choose will affect:

- **Size and type of heating system.** Any heating system can be installed with any ventilation system. Forced-air heating is convenient to install with balanced mechanical ventilation because the same ductwork can be used to supply heat and fresh air. When you use a heat recovery ventilator you can install a smaller heating system than is normally required.
- **Framing.** The ductwork for ventilation should be planned with your framing. If you combine heat-recovery ventilation with forced-air heating, you will not need separate air-supply ducts. Be sure to locate intake ducts to avoid contaminating incoming air with exhaust from furnaces, water heaters or the ventilation system.
- **Windows.** Plan for some openable windows and place them to allow cross currents on the same floor and air movement between floors.

Heating Systems

Principles

It is easy to oversize a heating system in an energy efficient home and important not to. An oversized system will go on and off too frequently, wasting fuel and shortening the life of the equipment. The output of your heating system should be 10 per cent higher than required to heat your home on the coldest day of the year. To choose a heating system of the right size, ask your contractor to do a heat load calculation.

With only 10 per cent excess capacity, you may find that it takes longer to warm your house on a cold morning after setting the thermostat back at night. An automatic setback thermostat will let you turn your furnace on earlier to overcome this problem in very cold weather.

Heating systems on the market are described in *Heating Systems*. You can choose between forced-air and radiant systems at a variety of efficiency levels. In addition to saving fuel mid- and high-efficiency furnaces and boilers use fans to exhaust combustion products. This eliminates the risk of dangerous backdrafts. The efficiency level you choose should make economic sense in your home; the smaller your heating requirements, the longer the payback period on higher-efficiency systems.

Related decisions

Your choice of heating system is affected by airtightness, levels of insulation, degree of solar gain, and type of ventilation system. It affects:

- **Framing systems.** Plan for ductwork if you choose a forced-air heating system and remember that radiant systems will still need ductwork for ventilation. **If you choose a floor radiant system, also plan to insulate under the floor to prevent excessive heat loss.**
- **Floor plans.** Some higher efficiency heating units do not need vertical chimneys. They use a horizontal chimney through the wall. This gives more flexibility in floor plans as there is no vertical chimney to locate through all storeys of the house.

Windows

Principles

Windows are weak points because they have a low insulation value and tend to be leaky. But they can gain heat from the sun. Windows lose heat two ways: by air leakage around the panes and heat flow through the glass. In an energy efficient house, air does not leak between the frame and the wall because the gap is well-sealed.

Windows describes how fixed windows leak the least amount of air because they are always sealed. For openable windows, choose designs that can be weatherstripped well: casement or awning types are best.

Different glazings have different insulation values. Windows with three panes of glass are better than windows with two. They have an extra dead air space to interrupt heat flow. This means that the inner pane is warmer than in double-pane windows, which reduces condensation. Some new windows achieve energy savings without the extra pane of glass. Low emissivity (low-e) windows use a coating that retards the transmission of heat to the outside. Research into new types of windows with high insulation values may someday eliminate constraints on window use in cold climates.

Related decisions

Airtight design allows higher humidity levels and can affect your choice of windows. Gas filled, low-e and triple-pane windows are less prone to condensation problems associated with high indoor humidity. Decisions about windows in turn affect:

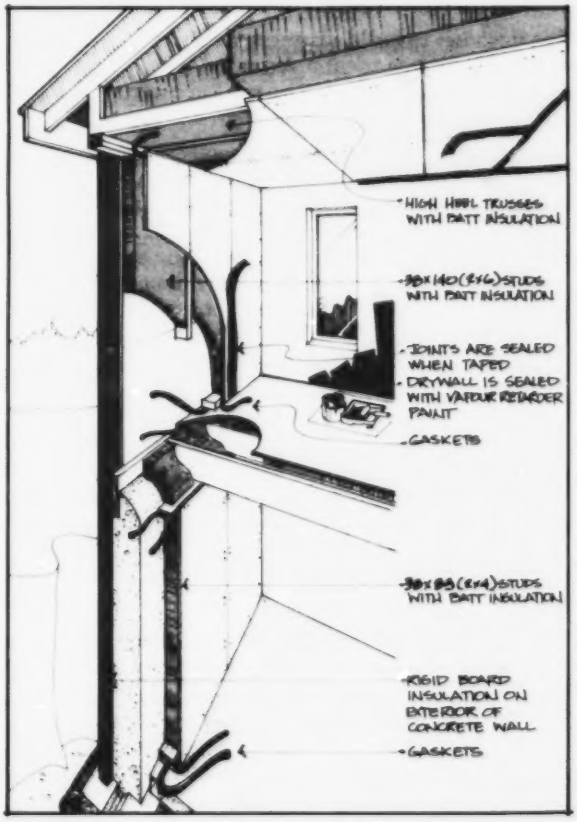
- **Degree of passive solar heating.** More windows on the south result in more solar gain. If you use a lot of south-facing windows for passive solar heating, you may want better than double-pane windows to cut down on heat loss at night. While triple-pane and low-e windows reduce the amount of incoming solar radiation, in our climate they more than make up for it in reduced heat loss.
- **Framing.** Decide whether your windows will go on the inside or outside of your framing cavity, which may be wider than conventional construction to accommodate higher levels of insulation. Plan ahead: you may be able to order window frames to match your wall depth.

Framing Options and Details

This section presents some options for framing foundations, walls and ceilings to achieve a well-sealed house with high levels of insulation. They are just some of the techniques used in energy efficient construction that are available and up-to-date.

As you would never build an energy efficient foundation, wall or ceiling in isolation, each framing option is presented as part of a total energy efficient house. The combinations presented here are ideas only. Use the options in different combinations to suit your needs, but remember to balance insulation values and pay attention to principles such as rules for placing vapour retarders inside insulated cavities. The systems are presented in order of increasing thermal efficiency.

System 1


HIGH HEEL TRUSSES WITH BATT INSULATION
38x140(2x6) STUDS WITH BATT INSULATION
JOINTS ARE SEALED WHEN TAPED
DRYWALL IS SEALED WITH VAPOUR RETARDER PAINT
GASKETS
38x89(2x4) STUDS WITH BATT INSULATION
RIGID BOARD INSULATION ON INTERIOR OF CONCRETE WALL
GASKETS

System 1

This illustrates a sealing technique called the airtight drywall approach. Sheets of drywall form an air barrier when they are sealed against the top and bottom framing plates with closed-cell foam gaskets and joined to each other with tape and plaster. The drywall is then covered with semi-gloss latex or vapour-retarder paint to act as the vapour retarder.

Concrete foundation insulated inside and outside, RSI 3.5-4.9 (R 20-28)

The basement is framed with 38mm x 89mm (2x4) lumber and insulated with batts. Rigid insulation is placed on the outside which protects the concrete from ground moisture and large temperature swings.

38mm x 140mm (2x6) walls insulated outside with rigid fibreglass, RSI 4.9 (R 28)

The wall is insulated between the studs with batts or blown-in cellulose and on the outside with rigid fibreglass. The combined air barrier and vapour retarder is formed with sealed, painted drywall.

Joist space, RSI 2.6 (R 15)

The joist space is insulated with the exterior cladding from the main wall and is sealed with gaskets. Batt insulation is placed on the inside. Remember to maintain the one third/two thirds rule.

High-heeled roof truss, RSI 7.0 (R 40)

This truss raises the roof rafters up off the top plate allowing an even depth of insulation throughout the attic. In conventional construction, the roof rafters rest on the top plate, restricting the space available for insulation at the eaves.

System 2

As it has no basement, this house incorporates more living space with a storey-and-a-half design. It is consistently strapped on the inside. To strap a wall, extra framing is nailed horizontally onto the main frame. Strapping inside is a convenient way to add insulation to storey-and-a-half construction because of the tight spaces in the sloped section of the ceiling.

MAINTAIN AIRSPACE
INSULATED AREA
AIR BARRIER AND VAPOUR RETARDER
BOARD INSULATION SEALED AROUND EDGES
BATT INSULATION IN 2ND FLOOR JOISTS
38x140 (2x6) STUDS WITH BATT INSULATION AND INTERIOR HORIZONTAL STRAPPING WITH BATT INSULATION
SILL GASKET SEALS BOTTOM PLATE TO SLAB
RIGID INSULATION BENEATH SLAB AND AT PERIMETER

System 2

Slab on grade with sill-plate gasket, RSI 0.9-1.8 (R 5-10)

Comfort is the main reason to insulate a floor. As all the living area in this house is on the slab, it makes sense. Insulation is placed around the perimeter to reduce heat loss from the edge of the slab. The slab is sealed to the bottom plate with a sill-plate gasket made of closed-cell or EPDM foam, and the combined air barrier and vapour retarder in the main wall is sealed to the bottom plate, making it continuous.

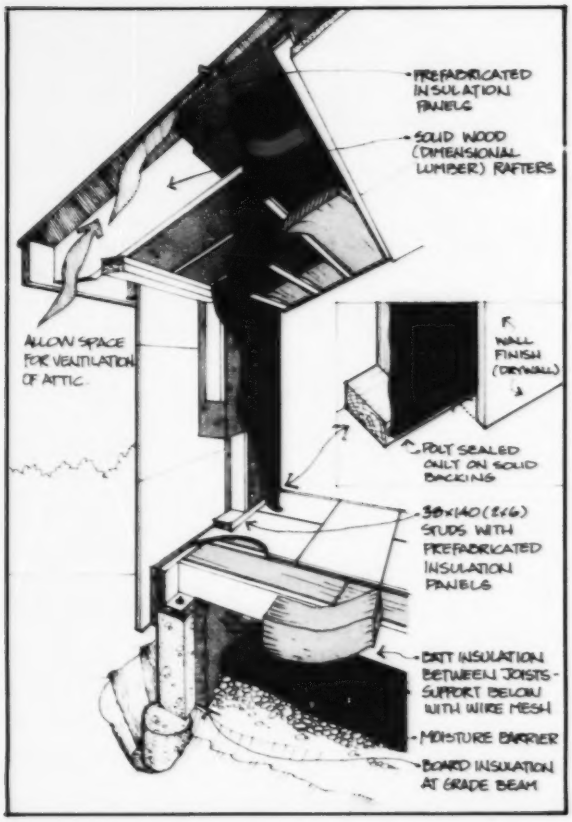
38mm x 140mm (2x6) wall, strapped inside, RSI 5.3 (R 30)

This conventionally framed wall is cross-strapped with 38mm x 64mm (2x3) lumber to create extra room for insulation. The combined air barrier and vapour retarder is installed between the studs and the strapping for protection.

Storey-and-a-half attic strapped inside, RSI 7.0+ (R 40+)

Strapping along the sloped section of the ceiling creates extra room for insulation in a tight place.

System 3


PREFABRICATED INSULATION PANELS
SOLID WOOD (DIMENSIONAL LUMBER) RAFTERS
ALLOW SPACE FOR VENTILATION OF ATTIC
WALL FINISH (DRYWALL)
POLY SEALED ONLY ON SOLID BACKING
38×140 (2×6) STUDS WITH PREFABRICATED INSULATION PANELS
BATT INSULATION BETWEEN JOISTS - SUPPORT BELOW WITH WIRE MESH
MOISTURE BARRIER
BOARD INSULATION AT GRADE BEAM

System 3

This system has balanced insulation levels. The money saved by building a crawlspace instead of a full basement is put toward a more expensive method of insulating the main walls.

Crawlspace sealed and insulated under the subfloor, RSI 3.5 (R 20)

In this system, the crawlspace is unheated. The foundation walls are insulated to keep temperatures inside the space above freezing. Note that the glued plywood subfloor, which is caulked at the joints and painted with a vapour-retarder paint, functions as an air barrier and vapour retarder. Vents framed into the concrete like windows allow the space to be ventilated in summer. The vents should be closed in winter to prevent the space from freezing.

200mm (8 in.) prefabricated rigid insulation wall panels, RSI 3.5-5.3 (R 20-30)

Some types come with studs imbedded in polystyrene insulation. Others supply rigid insulation panels with pre-formed slots for studs. The rigid polystyrene insulation contributes to the load-bearing capacity of the wall. Although polystyrene insulation has a lower permeability than some insulations, an air barrier and a vapour retarder may still be required.

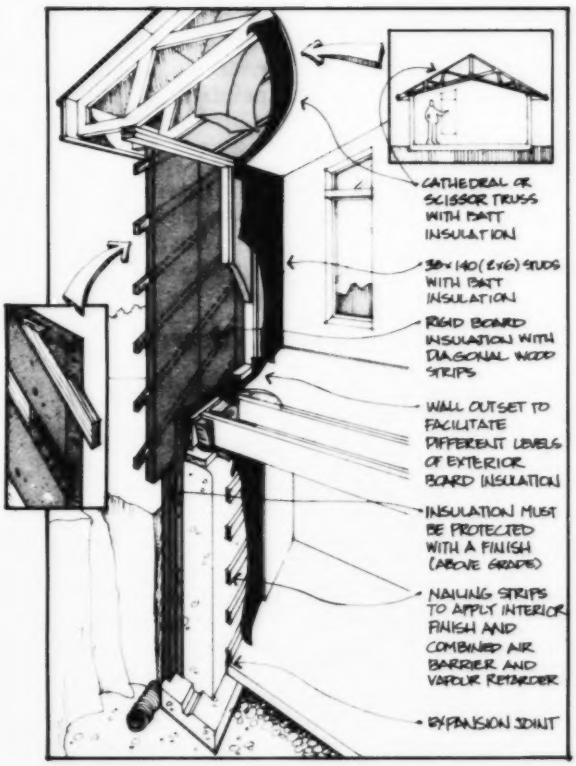
Joist space, RSI 3.5 (R 20)

The joist space is insulated at the same time as the floor.

Strapped cathedral ceiling, RSI 7.0+ (R 40+)

This is a conventionally framed cathedral ceiling with cross-strapping on the inside to make room for more insulation. Note that the combined air barrier and vapour retarder is in a protected position between the rafters and the strapping.

System 4


CATHEDRAL OR SCISSOR TRUSS WITH BATT INSULATION
38×140 (2×6) STUDS WITH BATT INSULATION
RIGID BOARD INSULATION WITH DIAGONAL WOOD STRIPS
WALL OUTSET TO FACILITATE DIFFERENT LEVELS OF EXTERIOR BOARD INSULATION
INSULATION MUST BE PROTECTED WITH A FINISH (ABOVE GRADE)
NAILING STRIPS TO APPLY INTERIOR FINISH AND COMBINED AIR BARRIER AND VAPOUR RETARDER
EXPANSION JOINT

System 4

This is a conventionally framed house that has external insulation throughout. It is well-insulated, but not super-insulated.

Concrete foundation, insulated outside, RSI 3.5 (R 20)

Certain rigid insulations can be used on the outside of foundation walls: type-two expanded polystyrene, extruded polystyrene and rigid fibreglass foundation insulation. Finish the insulation above grade to protect it. The combined air barrier and vapour retarder is on the inside against the concrete. Horizontal 19mm x 89mm (1x4) strapping provides a nailing surface for the finish. The strapping can be attached with concrete nails, as shown here, or can be cast-in-place.

38mm x 140mm (2x6) wall with polystyrene exterior cladding, RSI 5.3 (R 30)

This is a conventionally framed wall filled with batt insulation or blown-in cellulose and covered with rigid polystyrene on the outside. The diagonal strapping inset into the insulation braces the wall and replaces the usual plywood sheathing. It also provides a nailing surface for attaching siding or stucco wire. The main wall is outset 50mm (2 in.) to make an even outside surface with the basement insulation.

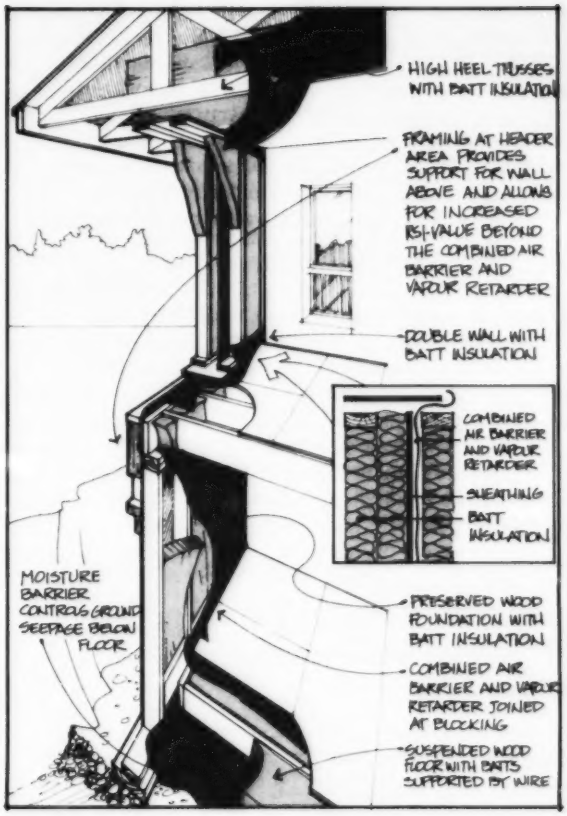
Joist space, RSI 5.3 (R 30)

RSI 1.8 (R 10) insulation from the basement and RSI 1.8 (R 10) from the wall cover the joist space on the outside. An additional RSI 1.8 (R 10) is added from the inside, respecting the rule that at least two-thirds of the insulation value must be on the cold side of the vapour retarder.

Scissor truss cathedral ceiling, RSI 7.0+ (R 40+)

This is a clear-span truss system: it requires no interior wall support. It allows air barriers, vapour retarders, and drywall to be applied continuously before building interior partition walls. The ceiling joists form a lower angle than the roof rafters, allowing high levels of insulation and good ventilation in the attic.

System 5


HIGH HEEL TRUSSES WITH BATT INSULATION
FRAMING AT HEADER AREA PROVIDES SUPPORT FOR WALL ABOVE AND ALLOWS FOR INCREASED RSI-VALUE BEYOND THE COMBINED AIR BARRIER AND VAPOUR RETARDER
DOUBLE WALL WITH BATT INSULATION
COMBINED AIR BARRIER AND VAPOUR RETARDER
SHEATHING
BATT INSULATION
MOISTURE BARRIER CONTROLS GROUND SEEPAGE BELOW FLOOR
PRESERVED WOOD FOUNDATION WITH BATT INSULATION
COMBINED AIR BARRIER AND VAPOUR RETARDER JOINED AT BLOCKING
SUSPENDED WOOD FLOOR WITH BATTS SUPPORTED BY WIRE

System 5

This is a super-insulated design that balances high levels of insulation through all parts of the house.

Wood foundation, RSI 3.5-4.9 (R 20-28) and suspended wood floor, RSI 4.9-6.0 (R 28-34)

Wood foundations are made of pressure-treated wood with fungicide to prevent the wood from rotting and with few exceptions it is assembled using conventional wood frame construction. It results in ready-made cavities for insulation. A moisture barrier under the wood floor prevents water from migrating into the cavity from the ground. In this system, a combined air barrier and vapour retarder is joined between the wall and the floor at 38mm x 89mm (2x4) lumber framed horizontally between the studs around the perimeter of the floor.

Double wall, RSI 7.0+ (R 40+)

A double wall is made of two conventional stud walls connected by top and bottom plywood plates. The total width of the wall, and thus the space for insulation, is determined by the width of these plates. Only the inner wall is structural. Note that the combined air barrier and vapour retarder is in a protected position, on the outside of the inner wall underneath the sheathing, and that two-thirds of the insulation value occurs outside it.

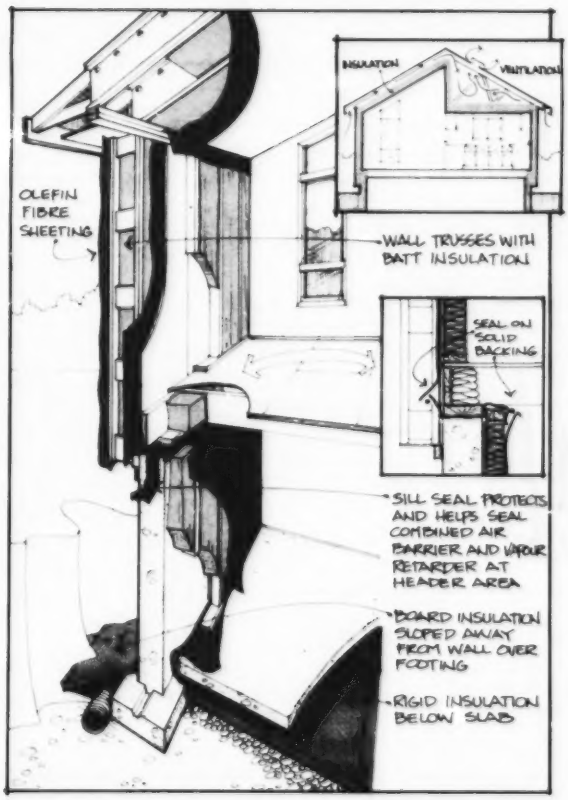
Joist space, R 3.2+ (R 18+)

The joist space is framed on the outside with 38mm x 89mm (2x4) lumber under the outer layer of the double wall. The framing sits on a ledge above grade. This allows RSI 2.1 (R 12) insulation outside the space and RSI 1.0 (R 6) inside. The space is sealed by wrapping a combined air barrier and vapour retarder around the headers and sealing it to the barrier/retarders in the main wall and foundation.

High-heeled roof truss, RSI 8.8+ (R 50+)

This system shows a high-heeled truss designed for RSI 8.8 (R 50) or better.

System 6


INSULATION
VENTILATION
OLEFIN FIBRE SHEETING
WALL TRUSSES WITH BATT INSULATION
SEAL ON SOLID BACKING
SILL SEAL PROTECTS AND HELPS SEAL COMBINED AIR BARRIER AND VAPOUR RETARDER AT HEADER AREA
BOARD INSULATION SLOPED AWAY FROM WALL OVER FOOTING
RIGID INSULATION BELOW SLAB

System 6

This is another super-insulated design with high levels of insulation throughout. The foundation is insulated on the inside to allow the truss from the main wall to cover the joist space without interference.

Concrete basement insulated inside, RSI 3.5-4.9 (R 20-28), with insulated slab, RSI 1.8 (R 10)

The walls of the basement are framed with outset 38mm x 89mm (2x4) lumber and insulated to RSI 3.5 (R 20). Rigid polystyrene insulation is used under the slab. The horizontal insulation outside the slab protects the footings from frost and the weeping tile from clogging with dirt.

Wall truss on 38mm x 89mm (2x4) wall, RSI 7.0+ (R 40+)

This is a non-structural truss -- added to the outside of a conventionally framed wall -- to create a cavity for insulation. The insulation level is determined by the depth of the truss. The combined air barrier/vapour retarder is in a protected position between the structural wall and the truss. As in any case where the vapour retarder occurs inside the wall, at least two-thirds of the insulation value is placed outside it. This diagram also illustrates an additional air barrier of olefin fibre sheeting on the outside of the wall.

Joist space, RSI 7.0 (R 40)

The joist space is well insulated with the same truss extension used on the main wall. It is sealed with a combined air barrier and vapour retarder wrapped under the header and joined with the barrier/retarder from the main wall. A sill gasket protects the barrier from damage by the concrete and provides an airtight joint, between the concrete and the wood sill plate.

Sloped truss cathedral ceiling, RSI 8.8+ (R 50+)

Trusses can be built to allow any level of insulation. This truss is structural and becomes the support for roofing and the interior finish.

Economics

This section looks at the economics of low energy homes by using an example. We have compared the utility and construction costs of similar houses, one built to conventional and and the other to energy efficient standards. **This economic analysis, of course, can not evaluate the health, comfort, safety and environmental advantages of low energy homes.**

The example house is a rectangular 108 square-metre (1160 square-foot) bungalow with a large area of south-facing windows (18.9 square metres or 203 square feet). We assume it has an RSI 6.0 (R 34) attic, RSI 3.5 (R 20) walls, a concrete foundation insulated on the inside with RSI 2.1 (R 12) batts, double-pane windows and 0.5 natural air changes per hour. This meets a higher standard than required by the Alberta Building Code but reflects the usual quality of a new home today. Table 2 outlines improvements beyond this basis resulting in a well-insulated, but not a super-insulated, house. The second column shows the added costs of the improvements and the third column lists the corresponding reductions in energy requirements in energy units (gigajoules or GJ). All costs are for Red Deer in 1990 dollars.

You can use these numbers to calculate how long it takes the energy efficient house to pay for itself in energy savings. Simple payback is calculated as the added cost divided by energy dollars saved each year.

$$\text{payback} = \frac{\$ \text{ more to build}}{\$ \text{ in saved energy/year}}$$

Before you can calculate payback, you need to convert the energy savings listed in column 3 to dollar savings. Column 4 shows units of energy rather than dollars because the amount of money saved depends on your heating system efficiency and the type of fuel it uses. For example, the house in Table 2 saves 74.8 GJ over its conventional version. You need to multiply this by the cost per GJ of the heating fuel. If it's gas and you live in Red Deer, the 1990 price is $2.12/GJ. You also need to divide by the decimal efficiency of your heating system to account for any fuel it wastes heating your home. In this example we assume a conventional 65 per cent efficient furnace and so divide by 0.65. If your furnace were 85 per cent efficient, you would divide by 0.85. With electric heating, which is 100 per cent efficient, you would divide by one.

Table 2
Comparative Costs and Energy Savings

Standard	Improved	Added costs	Annual Energy Savings (GJ)	Other Advantages
Foundation: full concrete RSI 2.1 (R 12)	Foundation: full contrete, RSI 3.5 (R 20) inside	$158	7.9	More comfortable walls
Walls: RSI 3.5 (R 20)	Walls: 38 mm x 140 mm (2x6) with polystyrene exterior cladding RSI 4.9 (R 28)	$809	6.8	More comfortable perimeter walls
Ceiling: RSI 6.0 (R 34)	Ceiling: RSI 7.0 (R 40)	$112	2.3	Sloped ceiling
Windows: double-pane throughout	Windows: triple pane throughout	$1213	24.3	Less condensation, noise transmission reduced
Ventilation: 0.5 natural air changes/hr., no mechanical ventilation	Ventilation: airtight (0.1 natural air changes/hr., 0.25 forced) with heat-recovery ventilation	$1903	33.5	Better indoor air quality
Totals:		$4195	74.8 GJ	

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